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Faculty Summit 2012

ADVANCING THE STATE OF THE ART

Towards Designing Sustainable Homes

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Towards Net-zero homes

energy gap

grid-only
pay electricity bill

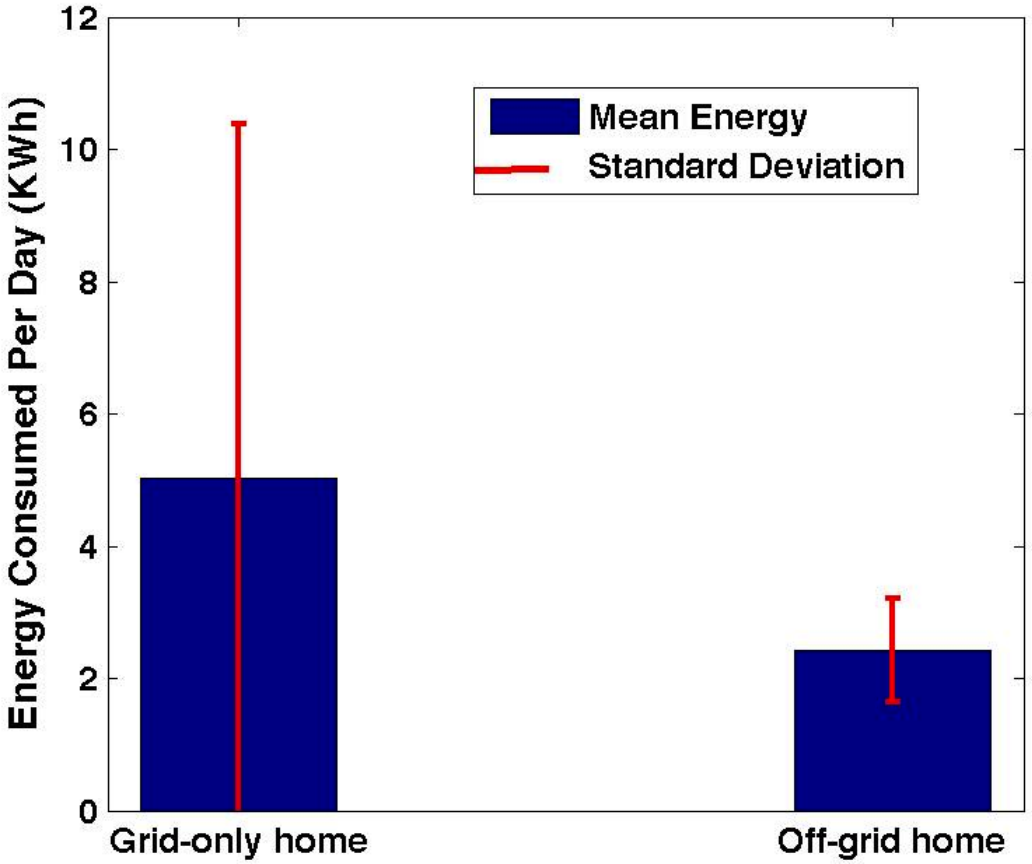
grid inter-tied
solar, wind, hydro

Off-grid
Solar, wind, hydro

Net-energy

Net-zero

Towards Net-zero homes



Energy budget **2-3x** less than grid-only

Question: how do we bridge this gap?

- more energy efficient technology
- usage behavior changes
- apply off-grid usage to grid-tied home

First Step: Collect real data

Automating Energy Management in Green Homes
N. Banerjee, S. Rollins, K. Moran, ACM Homenets 2011, Best Paper Award, CCR 2011

What are specific challenges in off-grid and grid-tied homes?

Performed online surveys for 8 households

- 4 off-grid, 4 grid-tied (CA, AR, MA, NE, Hawaii)
- wind turbines, solar panels (1.6 KW – 11 KW systems)
- auxiliary power sources such as diesel or propane generators

Need for non-intrusive energy monitoring visualization, control

"I have a Trimetric readout in the house but it has poor accuracy, it is fairly useless except for incoming and outgoing amps, I would like to be able to access my numbers without trekking up to the power shed and peering at the readout on the outback"

Several external factors effect energy generation

"mold soots due to oak trees on PV panels" affect power generation as well as "trees surrounding the home"

Need for automated or semi-automated demand and response systems

"I own a vacuum, but only use it on sunny afternoons when the batteries are full, as it is a HUGE energy hog. This means I vacuum a lot less than previously, but find a broom does a decent interim job."

Measurement infrastructure and incentives

Home component

Data collection

Appliance Control

Home OS

Vera2 driver

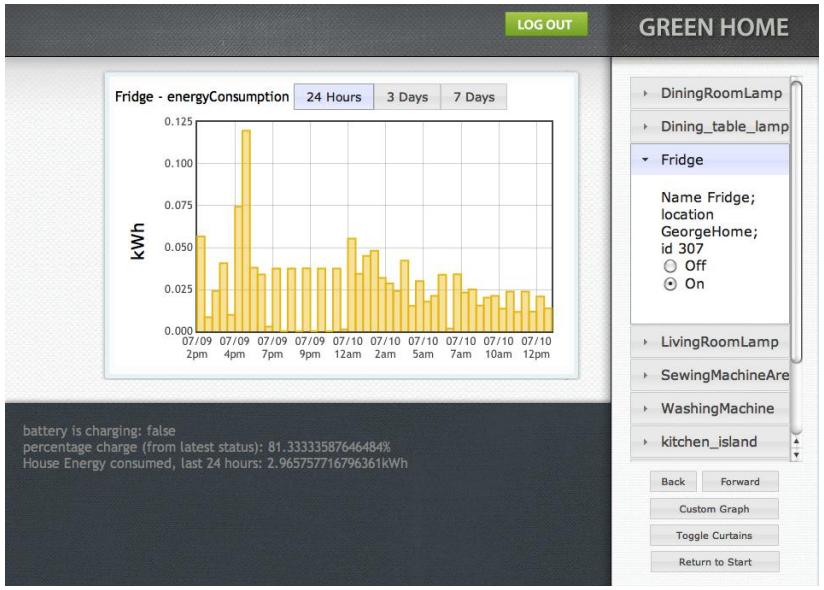
Server component

java servlet webserver

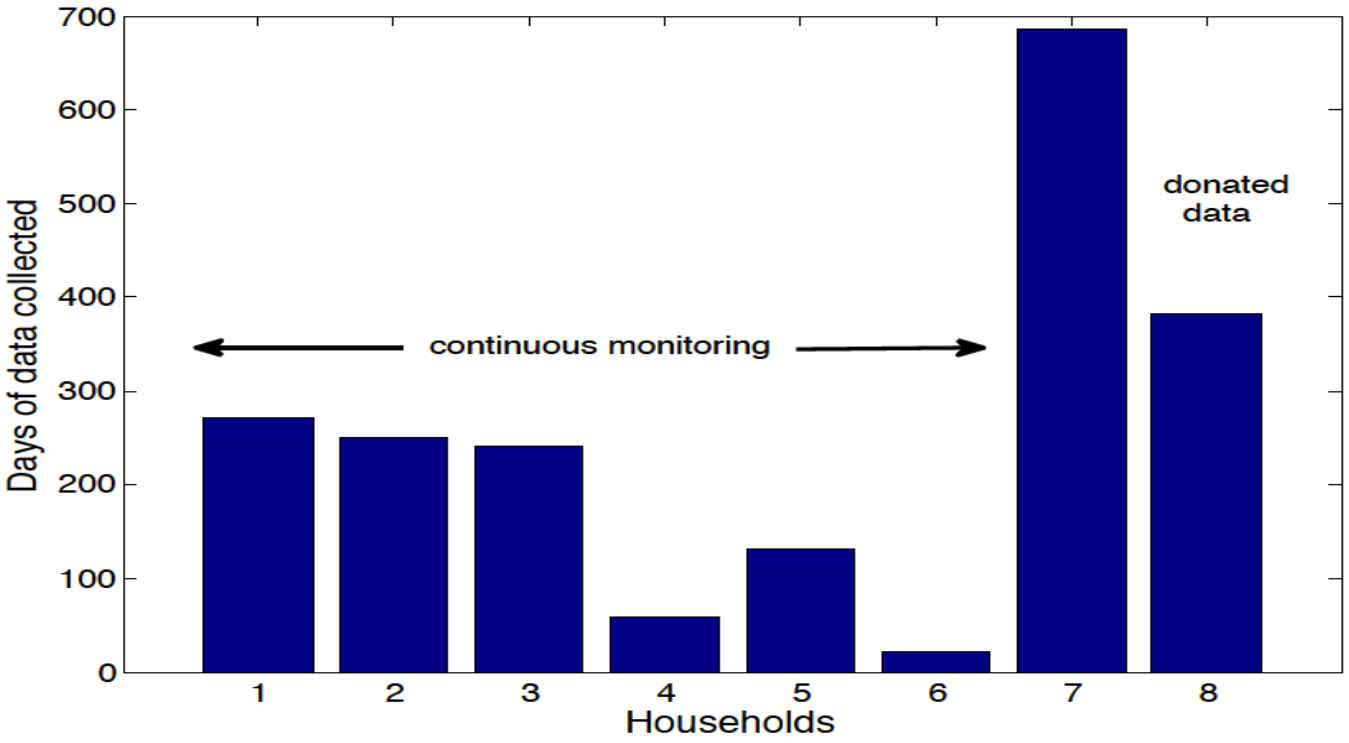
extensive REST API

database

third party apps?



Data collected till date

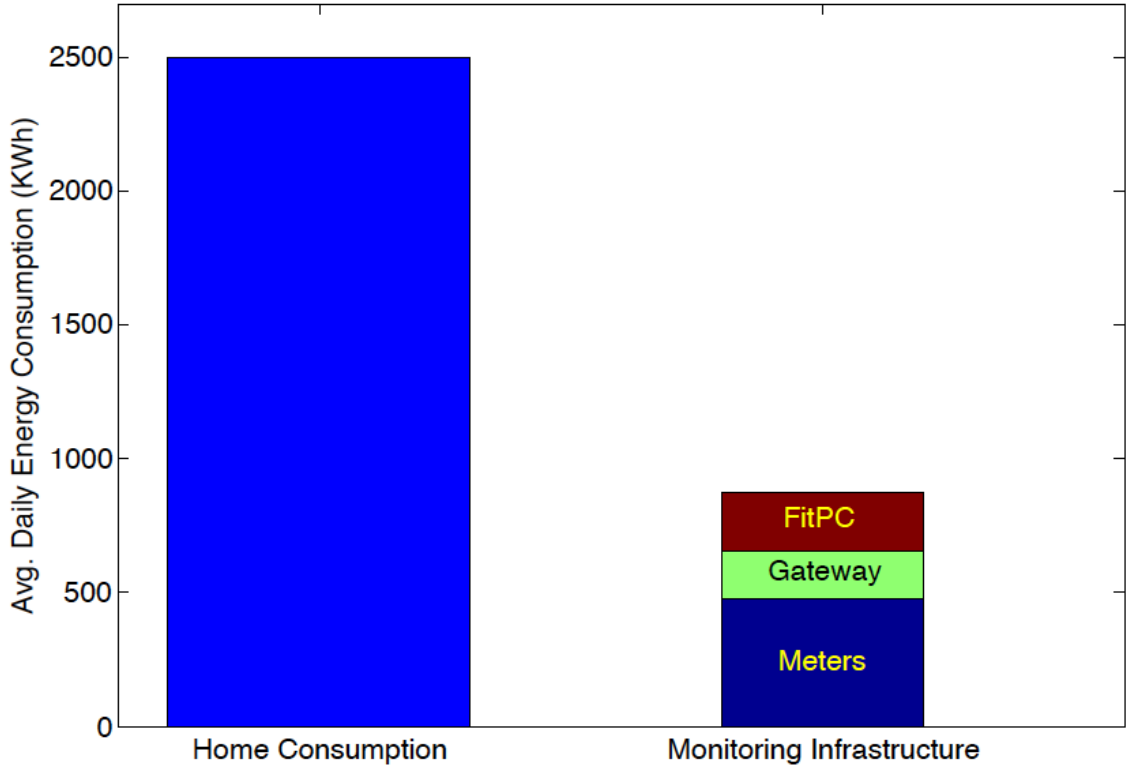


Data from 8 homes (continuous data from 6 homes)

- off-grid and grid-tied (4), grid-only (4) [> 4 GB of data]
- <total home energy, generation, consumption, appliance>
- 6 more off-grid and grid-tied homes have shown interest

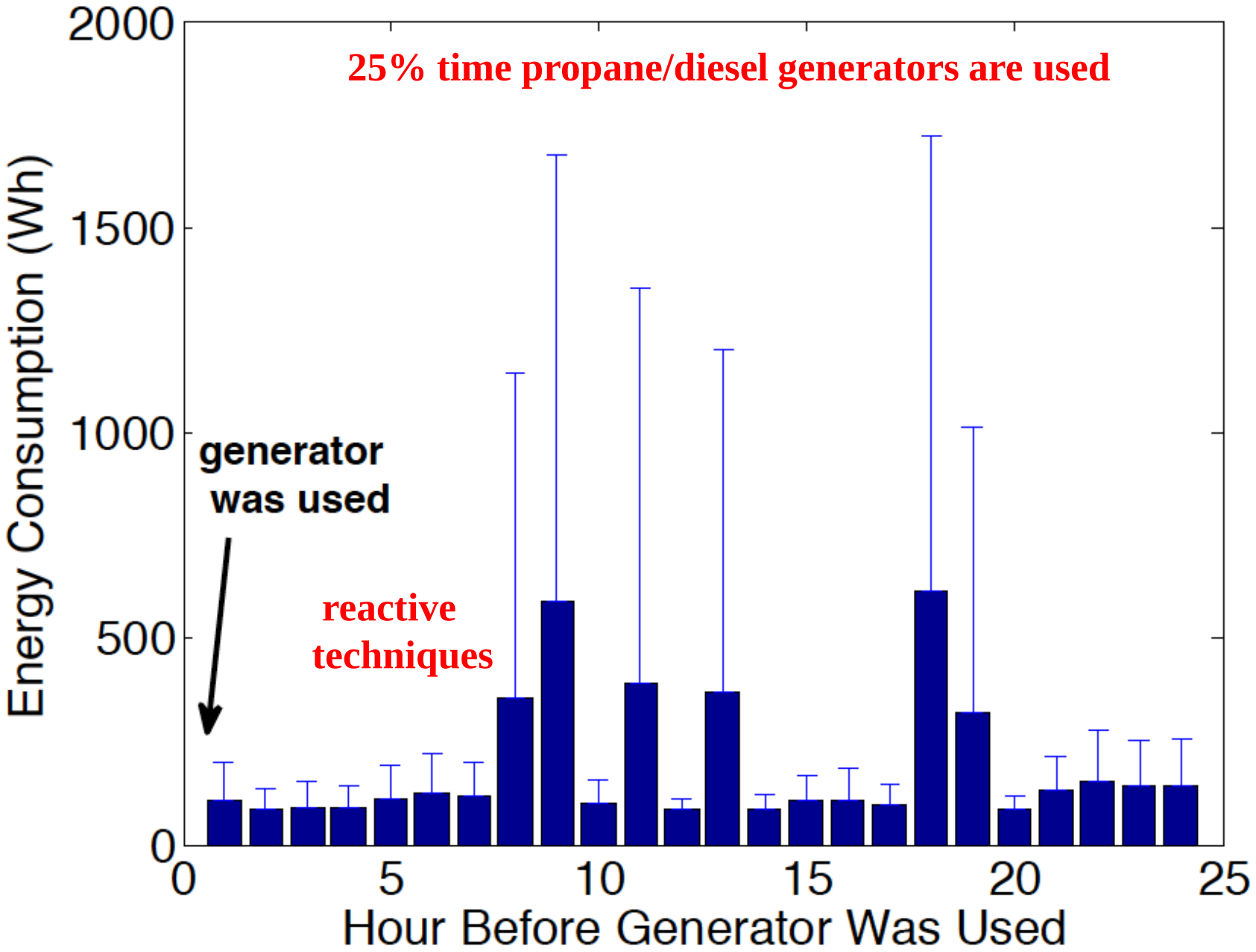
Non-intrusive energy monitoring

- Sampling Analysis
  - minimize energy/bandwidth overhead
  - capture outliers, energy peaks
    ON times
  - frequency spectrum for time of day
  - Nyquist criterion -> determine
    sampling rate
  - push based approaches, using other context

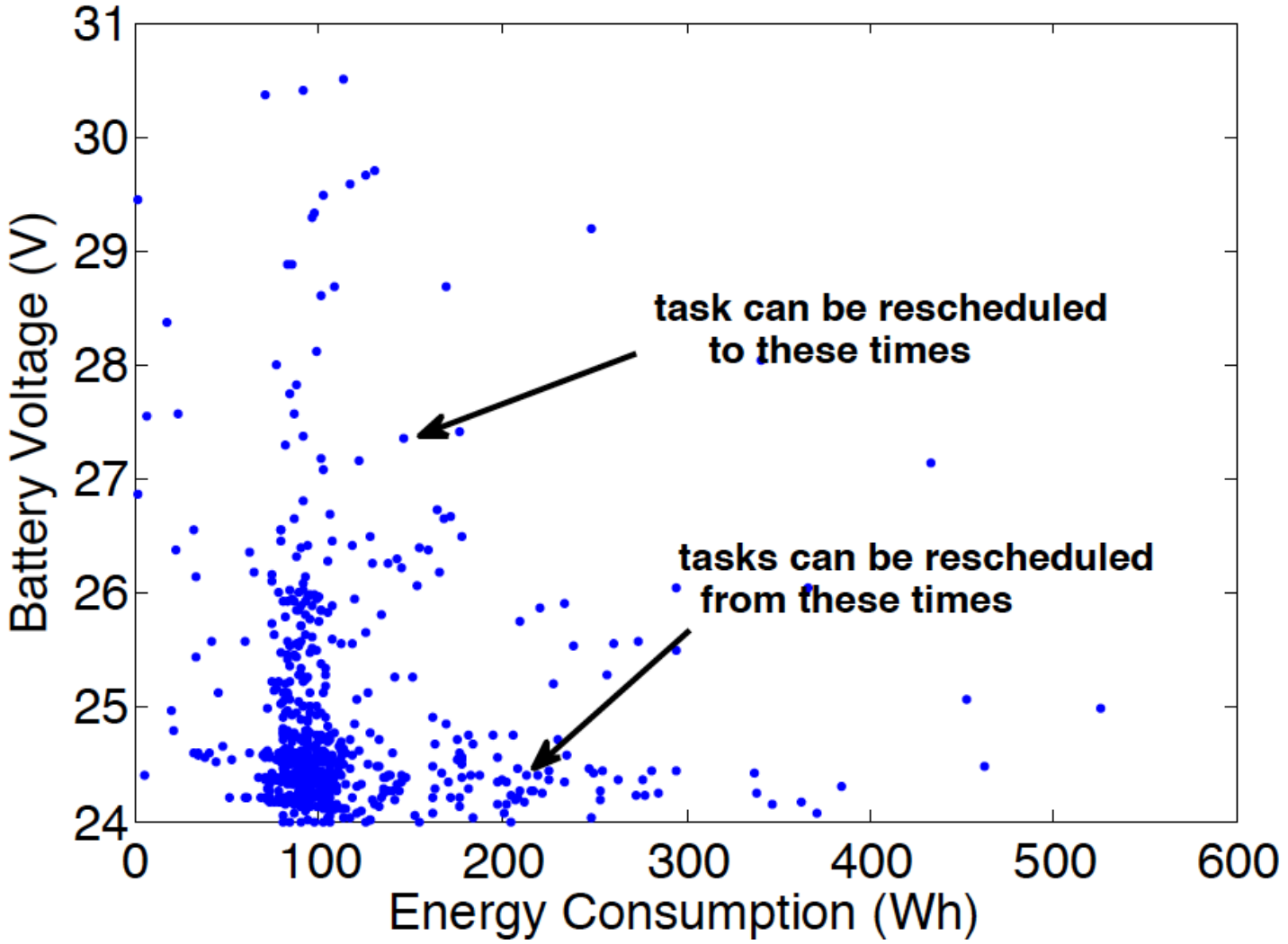


- Minimal set of appliances to monitor
  - devices that are to be controlled (TV, Lights, PCs) are monitored
  - use unsupervised learning (HMM) and generic profiles
    - determine usage of all appliance from devices monitored
    - recommend additional devices to be monitored

Insight: off-grid homes are not truly sustainable



Insight: opportunities for demand response



Energy savings

1500 - 2000 Wh

→

Equivalent to 2V

24V to 26 V

Far from conclusion..

- Wider and more robust monitoring infrastructure
  - collect context information through smartphone app, sensors
  - open platform for application development (social networking)
  - home automation for people with disabilities (gesture recognition using wearable nano-structured and fabric sensors)

- Build a recommendation based demand response system
  - off-grid, grid-tied, grid-only

- Understand the differences and similarities in energy consumption in the three types of houses
  - define a energy pathway towards net-zero paradigms

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